

STUDIES ON THE *GYMNOCARPIUM ROBERTIANUM* COMPLEX IN NORTH AMERICA

JAAKKO SARVELA, DONALD M. BRITTON AND KATHLEEN PRYER

Abstract: The cytology and distribution of *Gymnocarpium robertianum* (Hoffm.) Newman and *G. jessoense* (Koidz.) Koidz. subsp. *parvulum* Sarvela in North America are presented, together with the distinguishing features of these two species. *Gymnocarpium robertianum* is confirmed as a tetraploid species with $n=80$ and the newly recognized *G. jessoense* subsp. *parvulum* also has $n=80$.

In a previous paper (Sarvela, 1978) the senior author pointed out that of the six species of the genus *Gymnocarpium* in the world, two have a wide circumboreal range, *G. dryopteris* (L.) Newman and *G. jessoense* (Koidz.) Koidz., while the third species *G. robertianum* (Hoffm.) Newman, has a smaller distribution area.

The genus *Gymnocarpium* in North America was last treated by Wagner (1966). He considered there were two basic species over most of the circumboreal range to which he applied the names *G. dryopteris* and *G. robertianum*. In addition, he introduced "the apparent cross of *G. dryopteris* and *G. robertianum*" as a new species of hybrid origin with the name *G. heterosporum* W.H. Wagner. *G. dryopteris* subsp. *dryopteris* has been known as a tetraploid since the work of Manton (1950) and eastern Canadian material was examined by Britton in 1953 ($n = \text{ca. } 80$). The larger, tripinnate taxon of the Pacific Northwest, *G. dryopteris* subsp. *disjunctum* (Rupr.) Sarvela, is a diploid ($n = 40$) (Wagner 1966). This has been sufficient reason for some workers to recognize the diploid entity as a separate species—*G. disjunctum* (Rupr.) Ching—although the relationship between the diploid and the tetraploid is obscure.

New investigations (Sarvela, 1980) have indicated that the *Gymnocarpium robertianum* complex may include as many as four taxa, i.e. two species, *G. robertianum* and *G. jessoense*, and two hybrids, *G. heterosporum* W.H. Wagner (*G. dryopteris* \times *robertianum*) and *G. \times intermedium* Sarvela (*G. dryopteris* \times *jessoense*). Our studies indicate that *G. \times intermedium* is a common hybrid of wide occurrence. So much so that, when this taxon is identified by its aborted spores and reduced glandularity, many sheets and localities of *G. jessoense* subsp. *parvulum* Sarvela are eliminated from consideration. The other hybrid, *G. heterosporum*, is considered to be rare indeed.

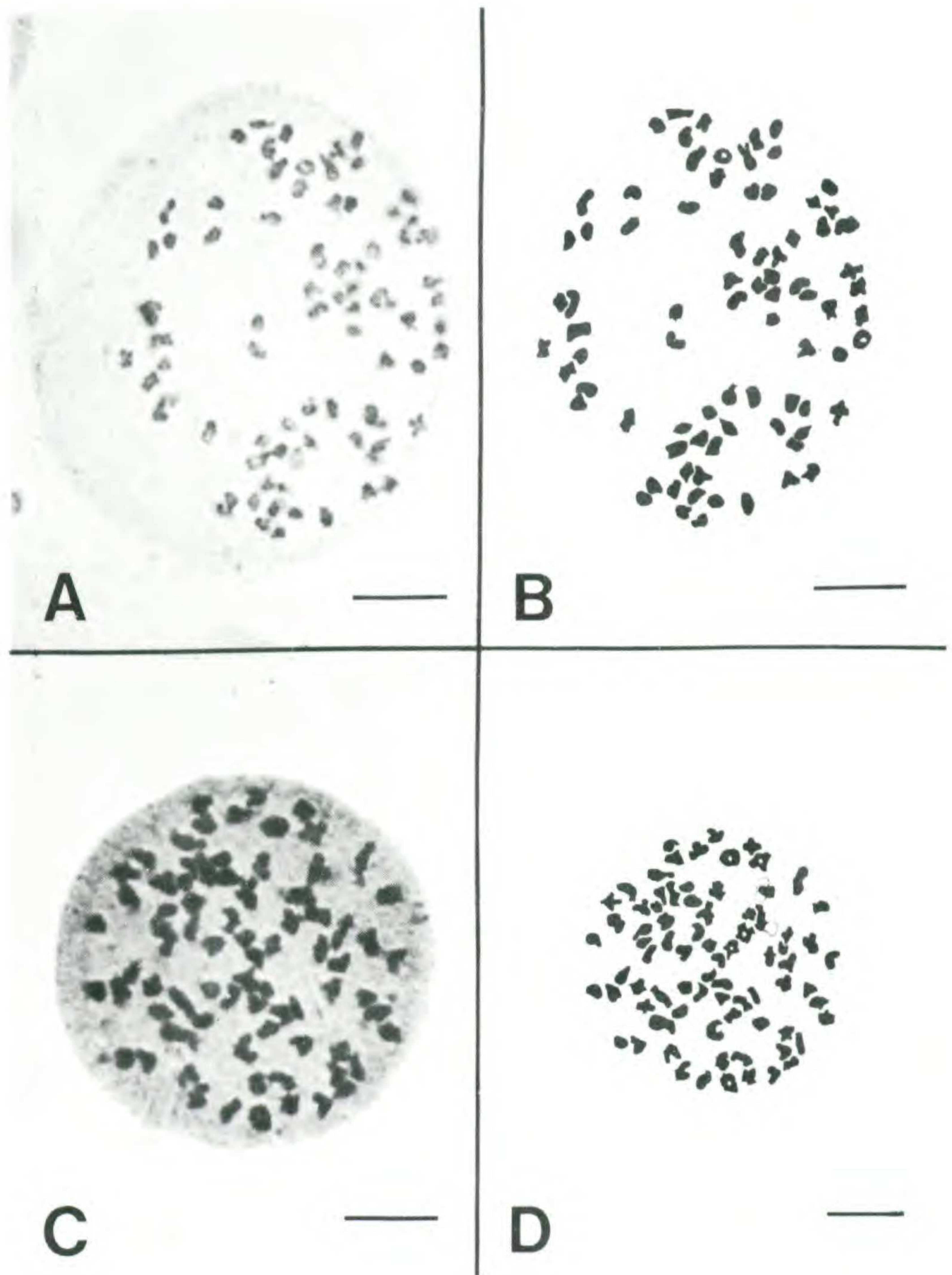


Figure 1. Chromosome numbers in *Gymnocarpium*. **A.** *Gymnocarpium jessoense* subsp. *parvulum*, $n = 80$ pairs, *K. Pryer 460* and *D. M. Britton*, from Pass Lake, Sibley, Ontario. **B.** Camera lucida interpretation of **A.** **C.** *Gymnocarpium robertianum*, $n = 80$ pairs, *K. Pryer 390* and *D. M. Britton*, from Bruce Peninsula, Ontario. **D.** Camera lucida interpretation of **C.** Bar represents 10μ .

Gymnocarpium robertianum s. str. is an amphiatlantic species growing in most of Europe, but in Asia it is limited to the Caucasus. In America it occurs from Newfoundland to Minnesota (Fig. 4). Both in Europe and America it seems to be restricted to limestone or calcareous habitats. It prefers to grow on the talus below limestone cliffs rather than in cliff crevices. It occurs not only in apparently dry habitats, but also occasionally in moist places; for example, in the Great Lakes region it may occur in *Thuja* swamps. *G. robertianum* has been known as a tetraploid species since Manton (1950). Material examined by us from Bruce Co., Ontario has $n = 80$ as one would expect (Fig. 1, C and D).

Two subspecies of *Gymnocarpium jessoense* can be distinguished. Subspecies *jessoense* occurs only in Asia from Afghanistan to Japan and southeastern Siberia. Material examined by Mitui (1970) in Japan was diploid with $n = 40$. The other subspecies, subspecies *parvulum* Sarvela, is circumboreal. The distribution area of the latter in Eurasia does not reach the Atlantic Ocean, ending in Finland; neither does it reach the Pacific in the East as pure subsp. *parvulum* but is intermixed with subsp. *jessoense*. In America the distribution of subsp. *parvulum* (Fig. 5) extends from Alaska to New Brunswick, but even here it is a continental taxon which is rare in areas close to oceans. Typical habitats for this subspecies are cool northern rock crevices. Therefore it remains usually small, the length of the leaf blade being mostly less than 12 cm. More information is required about its habit of avoiding dolomitic limestone, as well as about the habitats where tall specimens have been collected occasionally as seen in herbaria. *Gymnocarpium jessoense* subsp. *parvulum* is a tetraploid with $n = 80$ (Fig. 1, A and B), according to our investigation of Canadian material.

Gymnocarpium robertianum (Fig. 2) and *G. jessoense* (Fig. 3) can be distinguished with the naked eye by the aspect of the pinnules and lobes which in the former are mostly straight and form an angle of ca. 90° with the rachis of the pinnae. In the latter they are somewhat oblique and frequently somewhat curved. Since the position of the pinnules and lobes varies to some extent in different parts of the frond, the difference is best seen in central parts of the basal pinnae. In Europe, the proximal basispic pinnule of the basal pinna in *G. robertianum* is always much larger than the corresponding acroscopic pinnule (Sarvela, 1978). In America, this character is not as reliable.



Figure 2. *Gymnocarpium robertianum*. Voucher specimen, $n = 80$, D. M. Britton 6902 (OAC).



Figure 3. *Gymnocarpium jessoense* subsp. *parvulum*. Voucher specimen, $n = 80$, K. Pryer 423 (OAC).

The glands, including their stalks, on the main rachis of *Gymnocarpium robertianum* are longer (at least 10% of the glands reaching 50–70 μm) than in *G. jessoense*, which has almost all the glands of the rachis ca. 20–30 μm long, fewer than 1% reaching the length of 50 μm . In addition, the glands of the latter are seldom as close together as those of the former. The rule that the distance between the glands of *G. robertianum* is shorter than the glands, whereas in *G. jessoense* the distance is longer than the glands, seems to hold quite well. The spores of *G. jessoense* always have a tan or brownish colour which appears “glassy” and is quite similar to that seen for *G. dryopteris*. The spores of *G. robertianum* are deeper brown in colour. Detailed dimensions of spores are given in Sorsa (1980).

Material was examined from CAN, DAO, OAC, TRT, TRTE, QUE, SFS, QFA, NFLD, UNB, WIN, SASK, ALTA, UBC, V, UVIC, MIN, WISC, MICH, H, and s. Approximately 360 sheets were annotated by J. Sarvela or D.M. Britton. Representative collections to show the distribution of *G. robertianum* and *G. jessoense* subsp. *parvulum* in North America are listed below.

REPRESENTATIVE COLLECTIONS

Gymnocarpium robertianum (Hoffm.) Newman

CANADA. **New Brunswick:** Restigouche Co., Restigouche River, *P.R. Roberts and N. Bateman* 64-3942 (UNB); **Newfoundland:** Humber West Distr., Bay of Islands, *M.L. Fernald, B. Long and J.M. Fogg, Jr.* 1128 (WIS); Port au Port Distr., Port au Port Peninsula, *E. Rouleau* 3698 (CAN, DAO, NFLD); St. Barbe Distr., Bonne Bay, *E. Rouleau* 3345 (NFLD); St. John Bay, *M.L. Fernald, B. Long and J.M. Fogg, Jr.* 1129 (MIN, WIN); **Ontario:** Algoma Distr., 2 mi. n.e. of Boisey Lake, *K.A.L. Reading* in 1966 (CAN); Bruce Peninsula, Moore Lake, *P.V. Krotkov* 9618 (DAO); Carleton Co., Gloucester Twp., *H.A. Senn* 1906 (DAO); Frontenac Co., Ompah, *J. and G. Goltz* 436 (OAC); Kenora Distr., Lonely Lake, *R. Bell* 28417 (CAN); Manitoulin Island, Providence Bay, *C.O. Grassl* 5857 (MICH); Meldrum Pt., *C.O. Grassl* 5865 (MICH); Thunder Bay Distr., Blackwater River, Kitto Twp., *C.E. Garton* 7738 (DAO); Ravine Lake, Sibley Twp., *T.M.C. Taylor, S.T. Losee and M.W. Bannan* 77 (CAN); Timiskaming Distr., Haileybury, *E. Lepage and W.K.W. Baldwin* 8113 (CAN); **Quebec:** Anticosti Island, La Loutre River, *FF. Marie-Victorin and Rolland-Germain* 24408 (SFS, WIS); Bonaventure Co., Bonaventure River, *J.F. Collins, M.L. Fernald and A.S. Pease* 8 August 1904 (CAN, DAO, MIN, QFA, WIS); Charlevoix Co., Cap-a-l'Aigle, *L. Cinq-Mars, N. David and C. Bourque* 69-31 (DAO, QUE, SFS); Chicoutimi Co., Shipshaw River, *J. Cayouette* 73-481 (CAN, QFA, SFS); Gaspé Co., Grande-Rivière River, *M. Thibault* 10 August 1972 (QFA); Mistassini Terr.,

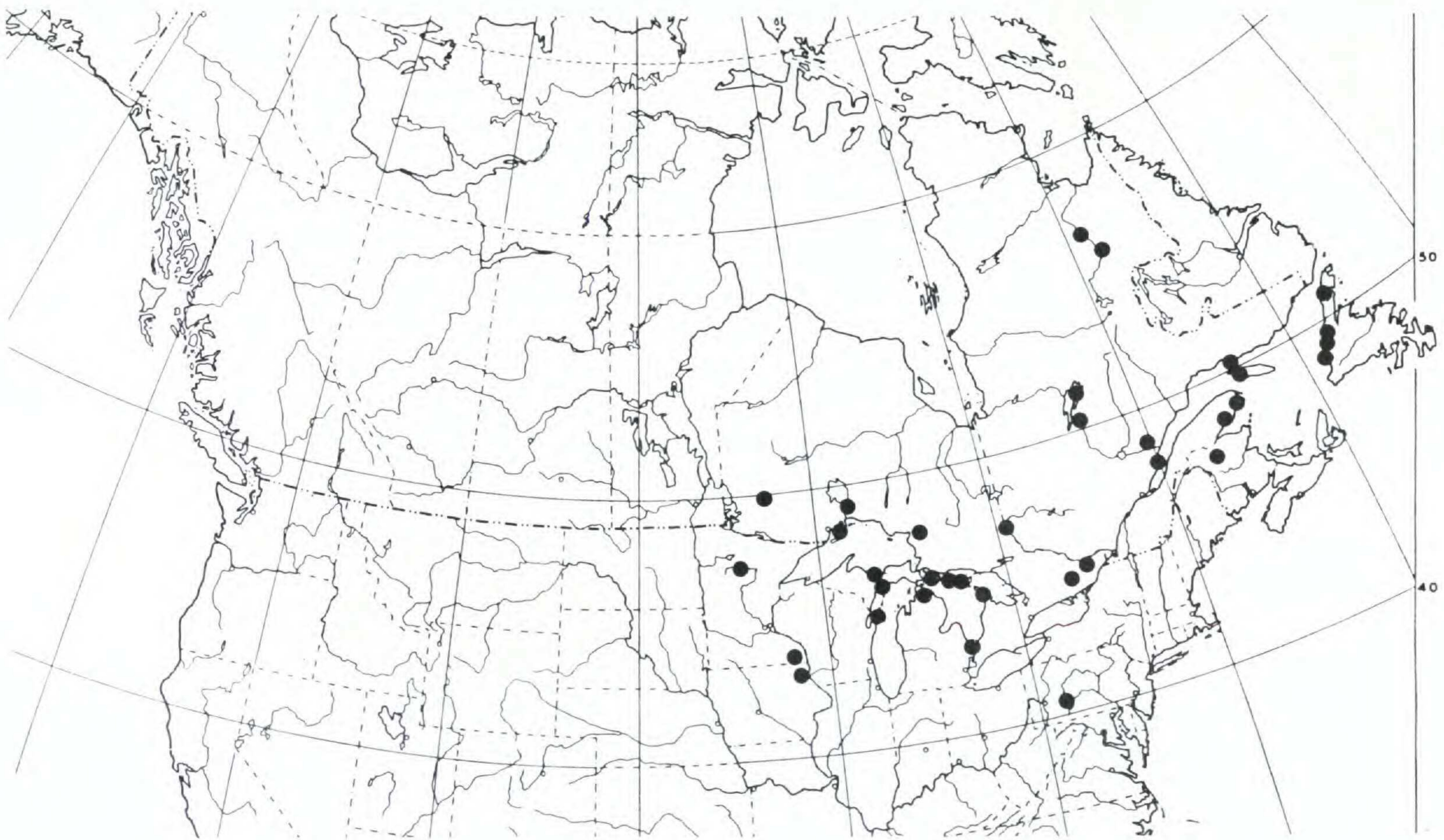


Figure 4. Distribution map of *Gymnocarpium robertianum*.

Mistassini Lake—Pointe Dutilly, *J. Rousseau* 1863 (QUE); Mistassini Lake—Peninsule du Dauphin, *J. Rousseau and E. Rouleau* 1132 (QUE); Nouveau Québec Terr., Caniapiscou River, *A. Dutilly and E. Lepage* 39433 (QFA); Swampy Bay River, *A. Dutilly and E. Lepage* 39290 (QFA, QUE); Saguenay Co., Archipel de Mingan—Grande Ile, *FF. Marie-Victorin and Roland-Germain* 18082 (SFS).

U.S.A. **Iowa:** Allamakee Co., Yellow River, *T.G. Hartley and R.F. Thorne* 6254 (WIS); **Michigan:** Cheboygan Co., Burt Lake, *C.D. La Rue* 13 August 1927 (MICH, WIS); Chippewa Co., Drummond Island, *R. McVaugh and Carroll E. Wood, Jr.* 11344 (MICH); Delta Co., Burnt Bluff, *M.L. Fernald and A.S. Pease* 3044 (MICH, WIS); Marquette Co., Presque Isle Park, *Dachuorski* 13 July 1906 (MICH); St. Clair Co., Port Huron, *C.K. Dodge* 6 October 1888 (MICH); **Minnesota:** Clearwater Co., 1.5 mi. west of Lake Itasca Post Office, *G.B. Ownbey* 3236 (DAO, MIN); Fillmore Co., 2½ mi. northwest of Wyboff, *J.W. Moore and N.L. Huff* 19870 (MIN); **Pennsylvania:** Blair Co., Duncansville, *L.K. Henry* 8 October 1957 (SFS); **Wisconsin:** Door Co., Ephraim, *A. Chandler* 40760 (WIS).

Gymnocarpium jessoense (Koidz.) Koidz subsp. **parvulum** Sarvela

HOLOTYPE: CANADA, **Northwest Territories**, Mackenzie Distr., Nahanni National Park, below Virginia Falls, *Teuvo Ahti* 31910 (H), isotype in DAO.

CANADA. **Alberta:** Jasper Park, North of Cavell Creek, *J.M. Macoun* 13 August 1917 (CAN); Lake Athabasca (north shore), Sand Pt., *H.M. Raup and E.C. Abbé* 4477 (CAN); Lake Athabasca, Shelter Pt., *H.M. Raup* 16 (CAN); **British Columbia:** Alaska Highway, (Mile 520), Liard River, *J. Grant* 23 (DAO); Alaska Highway, Beatton River, *H.M. Raup and D.S. Correll* 10269 (S, CAN); Cassiar Distr., Wheaton Creek, *A.F. Szczawinski* 25 July 1961 (DAO); **Keewatin:** Nueltin Lake - n.w. extremity at mouth of Windy River, *Francis Harper* 2361 (CAN, MIN); **Manitoba:** Fort Churchill, *W.B. Schofield and H.A. Crum* 7150 (CAN); Herb Lake, south end of Wekusko Lake, *H.J. Scoggan* 6584 (WIN, CAN, ALTA); Pipestone Lake, Entrance of Nelson River, *H.J. Scoggan* 3303 (CAN, WIN); Reindeer Lake, Paskwachi Bay, *W.K.W. Baldwin* 2387 (WIN, CAN); Scotty Lake, south of Flin Flon, *G.M. Keleher* 92 (WIN); Seal River, 2 mi. n.w. of Great Island, *J.C. Ritchie* 1936 (DAO); Tramping Lake (South end), *H.J. Scoggan* 6880 (MIN, ALTA, CAN); **New Brunswick:** Upper Restigouche, *J. Brittain*, 19 July 1888 (QK) photo in DAO; Restigouche River, *John Brittain*, July 1888 (CAN), on the same sheet *G. robertianum*. **Northwest Territories:** Eastern Great Slave Lake Region, 3 mi. n.e. of Mountain Lake, *E.A. Johnson, W. Harris, K. Traynor* 881 (SASK); Mackenzie Distr., Blackford Lake (southeast shore), *G.W. Scotter* 978 (DAO); Enterprise-MacKenzie River Highway (mile 15½), *J.W. Thieret and R.J. Reich* 5156 (DAO); Lac Du Mort (east side), *G.W. Scotter* 1142 (DAO); Nahanni National Park—north end of Liard Range, *Teuvo Ahti* 31909 (H); MacKenzie Mountains, Keele River, *W.J. Cody and G.W. Scotter* 19196 (DAO); MacKenzie River, Lone Mtn., confluence of the North Nahanni and the MacKenzie Rivers, *V.C. Wynne-Edwards* 8416 (CAN); MacKenzie River, Bosworth Lake—Norman Wells, *V.C. Wynne-Edwards* 8587 (CAN); **Ontario:** Algoma Distr., Michipicoten Harbour—1 mi. south of Helen, *R.C. Hosie, H.M. Harrison and E.O. Hughes* 1095 (CAN); Cochrane Distr., Missinabi River—Thunder House Rapids, *A. Dutilly and E. Lepage* 36272 (DAO); Kenora Distr., Patricia portion, 54° 31' N, 84° 53' W,

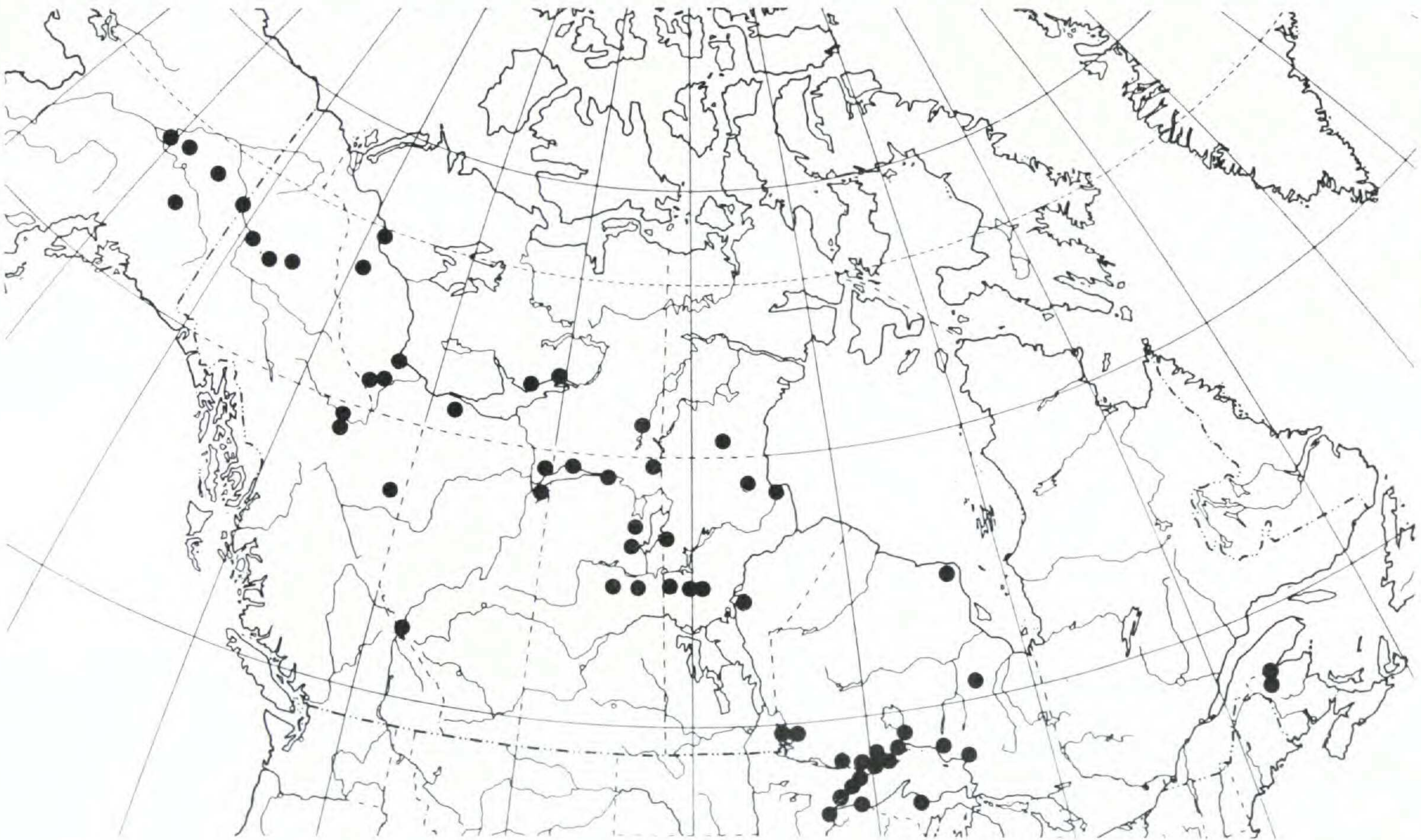


Figure 5. Distribution map of *Gymnocarpium jessoense* subsp. *parvulum*.

locality 352B, *J.L. Riley 9488* (TRT); McMeekin Twp., Andy Lake, *P.F. Maycock and D. Gregory 32728* (TRTE); south side of Hwy. 17 about 5 miles east of Manitoba border, *E. Medhurst EM-58* (OAC); Rainy River Distr., Quetico Provincial Park—Glacier Lake, *S. Walshe 76-179* (OAC); Thunder Bay Distr., Crooks Twp., *Cormack and Mayall 19 August 1936* (MICH); Cliffs of Current River bank at Trowbridge Falls, *C.E. Garton 1411* (DAO); Hardwick Twp., Roundtable Lake, *C.E. Garton 1497* (DAO); Kamanistiquwa River, *D.M. Britton, A. Anderson and C.E. Garton 6811* (OAC); ca. 25 mi. n.e. of Marathon, *E.G. Voss 11668* (TRT, MICH); Red Rock slope near Highway 17, *D.M. Britton and J.H. Soper 723* (OAC); Reflection Lake—6 mi. south of MacDiarmid, *C.E. Garton 7493* (OAC); **Saskatchewan:** Hansen Lake Road, Limestone Lake, *G.W. Argus and J.H. Hudson 4575* (DAO, SASK); Highway 102 (mile 6.7), 5 mi north of La Ronge, *V.L. Harms 21134* (SASK); Highway 105 (mile 56), 1.5 mi. south of Bothwell Lake, *J. Ternier and M. Jasieniuk 1783* (SASK); Lake Athabasca (east end), Chet Lake, *R.S. Campbell 30 July 1935* (CAN); Lake Athabasca, Cornwall Bay, *H.M. Raup 6568* (CAN); Patterson Lake, *G.W. Argus 361-63* (CAN, SASK, SFS); Wollaston Lake Road, Highway 105 (mile 107.5), *J. Ternier and M. Jasieniuk 2418* (SASK); **Yukon Territory:** Haggert Creek, near Keno Hill north of Mayo, *Catherine Broadfoot 18* (DAO, S); McQuesten Area, west of Sunshine Creek, *J.D. Campbell 476* (CAN); Moosehide Mtn., Dawson, *J.A. Calder and L.G. Billard 2963* (DAO).

U.S.A. **Alaska:** Canyon Creek, Mile 301 Richardson Highway, *W.J. Cody and T.J.M. Webster 5524* (DAO); Livengood, 80 mi. n.w. of Fairbanks, *Edith Scamman 1679* (MIN, CAN); Miller House, 115 mi. north of Fairbanks on Steese Highway, *Edith Scamman 1972* (SASK); Taylor Highway (mile 156), 6 mi. south of Eagle, *V.L. Harms 4872* (SASK); Yukon River, between Rampart and Tanana, *L.J. Palmer 39* (CAN); **Michigan:** Marquette Co., ca. 6 mi. n.w. of Ishpeming, *E.G. Voss, W.H. Wagner, Jr., and D.J. Hagenah 4709* (MICH); **Minnesota:** Cook Co., Watab Lake, *F.K. Butters, E.C. Abbé and L.B. Abbé 226* (MIN); Lake Co., 4 mi. west of Illgen City, *N.C. Fassett and J.T. Curtis 19217* (WIS); Pine Co., Cliffs of Kettle River, *F.K. Butters June 1935* (MIN); St. Louis Co., Gooseberry River, *G.H.C., and M.F. Somerville 832* (WIS); **Wisconsin:** Bayfield Co., Orienta Falls (Iron River), *M.F. Somerville 1125* (WIS, DAO).

EXCLUDED RECORD

Conn., Fish Hatchery west of Hartford, 11-19-1924, *G.H.C. 831* (WIS). No species of this alliance are listed in "Rare and Endangered Vascular Plant Species in Connecticut" (1978).

LITERATURE CITED

- BRITTON, DONALD M. 1953. Chromosome studies in ferns. *Amer. J. Bot.* **40**: 575-583.
- MANTON, IRENE. 1950. Problems of Cytology and Evolution in the Pteridophyta. Cambridge.
- MITUI, KUNIO. 1970. Chromosome studies on Japanese ferns (4). *J. Jap. Bot.* **45**: 84-90.

- SARVELA, JAAKKO. 1978. A synopsis of the fern genus *Gymnocarpium*. Ann. Bot. Fenn. **15**: 101-106.
- . 1981. *Gymnocarpium* hybrids from Canada and Alaska. Ann. Bot. Fenn. (in press).
- SORSA, PENTTI. 1980. Spore morphology of the fern genus *Gymnocarpium* and its relations to the taxonomy. Ann. Bot. Fenn. **17**:86-90.
- WAGNER, WARREN H. JR. 1966. New data on North American Oak ferns, *Gymnocarpium*. Rhodora **68**: 121-138.

J. SARVELA,
BOTANICAL MUSEUM,
UNIVERSITY OF HELSINKI,
UNIONINKATU 44, SF-00170,
HELSINKI 17, FINLAND.

D.M. BRITTON AND K. PRYER,
DEPARTMENT OF BOTANY AND GENETICS,
UNIVERSITY OF GUELPH,
GUELPH, ONTARIO.
N1G 2W1